The Thesis Committee for Vanessa Ysabel Urrutia certifies that this is the approved version of the following thesis:

How Problem Solving Reasoning of Third-Grade Students Differs Between English Language Learners and Non-English Learners

Committee:

Sarah Powell, Supervisor

Marcia Barnes

Diane Bryant

North Cooc

How Problem Solving Reasoning of Third-Grade Students Differs Between English Language Learners and Non-English Learners

by

Vanessa Ysabel Urrutia, B.S.H.D.F.S.

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Dedication

This thesis is dedicated to all of the children who are learning English as a second language. I understand the arduous task of learning English while also developing in one's own language. Being a first generation American that grew up speaking Spanish has been difficult yet rewarding. My experiences learning English as a second language garnered an interest in the growth and development of students with ELL needs.

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Abstract

How Problem Solving Reasoning of Third-Grade Students Differs Between English Language Learners and Non-English Learners

Vanessa Ysabel Urrutia, MA

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Supervisor: Sarah R. Powell

This study examined the problem solving reasoning abilities of third-grade students, characterized as English Language Learners and non-English Language Learners. Data were collected under the current longitudinal study, University of Texas at Austin (UT) Word Problem Project, conducted by special education faculty at the UT. This study started in 2015 and currently is in progress through 2019. Participants were served in third-grade classrooms across the local school district. As a part of the UT Word Problem Study, students were audio recorded when administered pretest assessments as baseline for the study. The current study transcribed the audio files to determine if English Language Learners approached math problems and solved math problems differently, as compared to non-English Language Learners.

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CHAPTER ONE: INTRODUCTION

Introduction

The performance of elementary students in mathematics serves as a significant predictor of how students will perform in middle school and high school (Stevenson & Newman, 1986). The classes that students take in middle school and high school also can determine college acceptance to and scholarship qualifications (Megert, 2005). College acceptance provides a stepping stone for students' future careers, and mathematics achievement proves a critical entry point for students' success. Achievement in mathematics is measured with standardized tests, such as the National Assessment of Educational Progress (NAEP). Standardized tests like the NAEP typically use word problems to evaluate mathematics skills. Solving word problems requires one to be able to read the problem, identify critical information, and determine how to solve the problem (Powell, 2011). Word-Problem solving may prove especially difficult for a specific group of students: English Language Learners (ELLs).

ELLs are classified as students who are 3-to-21 years-old, enrolled or planning to enroll in school, born outside of the United States or whose native language is not English, and have difficulties when reading, writing, and speaking English (No Child Left Behind [NCLB], 2002). ELLs typically are identified first Home Language Surveys, and later through district assessments. After the Home Language surveys are issued, the districts administer a language proficiency assessment to determine if a student qualifies as an ELL (Linquanti & Cook, 2013). Data from the most recent NAEP fourth-grade

mathematics assessment indicates that ELLs perform significantly below their native English peers or non-ELLs (NAEP, 2015). The NAEP data also shows that ELLs perform significantly below their native English peers within each racial category (NAEP, 2015). Based on this data, the present study examined the rationale that ELLs provided in oral responses for how they solved word problems, as compared to the responses of non-ELLs.

In the classroom and during state assessments, students are evaluated using word problems and are expected to interpret their answers in written or verbal form. This can prove especially hard for ELLs who may be unfamiliar with the vocabulary used within mathematics word problems. In Martiniello's (2008) analysis of language and ELLs performance, she showed that ELLs struggled with unfamiliar English vocabulary and syntax structures. Difficulty understanding English vocabulary and syntax structures can affect how ELLs perform in early mathematics courses and state assessments. Additional researchers (e.g., Cawthon et al, 2013) determined that current test items that are 'standardized' confound the scores of students who come from diverse backgrounds. Thus, the assessments used to evaluate ELLs are not culturally responsive by assuming that ELLs will understand the context in which the problems are presented.

In early elementary mathematics, students are expected to understand and solve word problems and explain the rationale behind their answers. In a recent study, Abedi and Lord (2001), examined the performance of ELLs and non-ELLs on NAEP assessments and a modified NAEP assessment. On the modified NAEP assessment, the questions were revised to be less linguistically complex to reduce the performance gap

between ELLs and non-ELLs but the items were still equivalent. ELLs scored lower on the non-modified math assessment than the non-ELLs. However, for the modified assessments, the ELLs demonstrated a slightly higher improvement percentage than the non-ELLs, when looking at the modified assessment, and this improvement was due to the language modification.

Language serves as an essential key to learning of all academic subjects, including mathematics (Cummins, 1988). Many believe that mathematics is universal because it involves numbers; however, the presentation of mathematical concepts to students (i.e., word problems) is through language and text (Cummins, 1988). Studies show that students perform worse on word problems than on problems presented in numerical form (Carpenter, Corbitt, Kepner, Linquist, & Reys, 1980). When solving word-problems, student must first decipher the text and determine which information is needed and which information is irrelevant. This task may prove difficult for students who are in the process of learning the English language and are being presented with word problems in English. A study conducted by Ríordáin (2008) examined the relationship between performance on mathematical word problems and language proficiency, and determined a relationship between language proficiency and mathematics performance. Another study in New Zealand conducted by Neville-Barton and Barton (2005) found that students who are learning a second language suffer a disadvantage in mathematics of between 12 to 15% due to English-language difficulties. ELLs struggle with language and mathematics, both of which are predictors of later school success, therefore a significant need exists to examine oral responses within word-

problem activities to understand how their oral responses differ from non-ELLs to ensure they receive the appropriate supports

Purpose of the Present Study

The present study examined the differences between the oral response rationales provided by ELLs and non-ELLs on how they solved word problems. Given that ELLs perform at lower rates in mathematics, a significant need exists to understand how ELLs use of language to describe word problems differs from their native English speaking peers. Based on the study's findings, implications for future research and practice are discussed.

CHAPTER TWO: METHOD

The UT Word Problem Project is a randomized control trial designed to evaluate the efficacy of a research-validated word-problem intervention program known as Pirate Math. The Pirate Math program utilizes schema and equation-solving instruction to support third-grade students who present with mathematics difficulty (MD) to solve word problems. During the 2015 to 2016 school year, students with MD were randomly assigned to one of the three conditions: Pirate Math Equal Sign (PMES), Pirate Math alone (PM alone), and a business-as-usual control comparison group. During the first year of the program, 14 elementary schools in Austin Independent School District participated in the study. Within the 14 elementary schools, 1,111 third-grade students were screened, and students who performed <13th percentile on a word-problem measure (Jordan & Hanich, 2000) were identified as at-risk for MD and deemed eligible for the study. Eligible students (n = 152) were randomly assigned to either receive the PMES or PM alone word-problem intervention (n = 102; 88 in the final analysis) or to participate in a business-as-usual comparison group (n = 50; 42 in the final analysis). Initially, 102 students were assigned to one of the two intervention programs (i.e., PMES or PM alone), but during the school year several students moved and were unable to continue with the intervention.

Within both the PMES and PM alone intervention conditions, tutors discussed three different additive problem types: Total, Difference, and Change problems. A total problem consists of putting parts together into a total; a difference problem compares two amounts for a difference; and a change problem has a start amount that increased or

decreases to a new amount. The word-problem intervention for both experimental groups included 48 one-on-one lessons, implemented three times a week, with each session lasting about 30 min. Each lesson consisted of five activities including (1) math fact flash cards, (2) equation solving practice for the PMES group and 2 min of reading for the PM alone group, (3) tutor-led lesson featuring schema instruction, (4) schema sorting practice, and (5) cumulative review. In Activity #1, tutors showed math fact flash cards to students during two, 1-min timings. This task enabled students the opportunity to practice basic math facts (e.g., 2 + 3, 11 – 7). In Activity #2, students in the PMES group received equation-solving instruction, and learned that the equal sign serves as a balance to both sides of an equation. Students in the PM Alone group participated in 2 min of book reading to control for intervention length. In Activity #3, tutors instructed students to solve addition and subtraction problems, and provided scaffold instruction to set up and solve three additive word-problem schemas: total, difference, and change. In Activity #4, interventionists read aloud word-problem flash cards for 2 min as students identified the problem type. In Activity #5, students participated in a paper-and-pencil review, which consisted of completing 9 addition and subtraction math equations in 1 min and one word-problem in 2 min.

Prior to implementing the mathematics interventions, the research team administered a set of pretesting assessments across multiple cognitive and mathematical measures to all eligible students to collect baseline data. The research team included Graduate Research Assistants (GRAs) from the Special Education department at the University of Texas at Austin. The 13 GRAs were recruited from the University's special

education programs, trained on testing and tutoring protocols, and taught to implement testing and tutoring sessions with fidelity. At the outset of the study, each GRA attended three training sessions before they worked with students. The GRAs were trained on how to administer whole-class screenings, pretest and posttest assessments, and the intervention protocol for PMES and PM alone students. The pretest battery consisted of multiple math assessments, including the *Wisconsin Card Sorting Task*, *KeyMath3*, and *Working Memory Test Battery Counting Recall* (add citations of researchers who created these tests). Of particular interest to this paper is the final portion of one of the pre-testing assessments, Texas Word Problems (Powell & Stevens, 2015), which was administered to understand the connection between how students solved word problems using written work and how students orally explained their word-problem work.

In the last section of the Texas Word Problem assessment, students were required to solve five word problems and subsequently explain how they solved each problem. The five word problems in the last section of the Texas Word Problems assessment are as follows:

- Problem S: *Mark has 11 blue and red crayons. If 7 of the crayons are red, how many are blue?*
- Problem T: *Stephanie had some pencils in her backpack. Then, 5 pencils fell out on the way home from school. Now, she has 9 pencils in her backpack. How many pencils were in Stephanie's backpack to start?*
- Problem U: *Maria has 4 more books than Juan. Juan has 5 books. How many books does Maria have?*

- Problem V: *There were 7 birds sitting in the tree. Then more birds flew into the tree. Now there are 13 birds in the tree. How many birds flew into the tree?*
- Problem W: *How many fewer students like swimming than soccer?* – the students were provided a graph with student's favorite sports: swimming, football, basketball, and soccer.

During administration of the Texas Word Problems, which was administered individually to each student, the GRAs read each problem to students and reread each problem upon request. The GRAs only read the problem up to two times. After the students finished working the problem, the GRA prompted the students, "How did you solve this problem?" The GRA also was provided with two follow up questions if students' responses were vague. The follow up questions were, "What is your answer?" and "How do you know?" For example, if the student answered by saying "I added" the follow up questions would be asked to allow them to elaborate.

The researchers systemically analyzed transcriptions from audio files that contained responses provided by ELLs and non-ELLs in the study on the final portion of the Texas Word Problems assessment. In total, 149 students were administered the pretest battery. To ensure the confidentiality of participants in the study, all students were assigned an identification number in place of their names. Of the 149 students, 75 were identified as ELLs and 63 as non-ELLs. Eleven students had missing data because they moved out of the area. A random number generator was utilized to select student identification numbers for participation in the transcription analysis; 18 ELLs and 23 non-ELLs were randomly selected.

The ELL status of students was confirmed by the teachers, who completed demographic forms on their participating students. This status was determined by the Texas English Language Proficiency Assessment System (TELPA). TELPAS is designed to assess the progress of students who are learning English. There are five domains within the TELPAS: listening, speaking, reading, writing and comprehension. When the TELPAS is administered to students, they are scored based on their level of proficiency. For the beginner level the students received a "B;" for the intermediate level the students receive an "I;" for the advanced level students receive "A;" for the advanced high level students receive "AH." The scored for the participants of this study are provided below.

Table 2.1 Student Demographics for ELLs

Id	Sex	Race	TELPAS LISTENING	TELPAS SPEAKING	TELPAS READING	TELPAS WRITING	TELPAS COMP.	YEAR RETAINED
10213	M	IRAQI						0
11005	M	HIS						0
12017	M	HIS	I	I	I	I	2	0
12107	F	HIS	A	A	I	I	2.2	0
12404	F	HIS	I	I	I	I	2	0
12515	M	ASIAN	I	I	I	I	2	0
12704	M	HIS	B	B	B	B	1	0
13606	F	HIS						1
14219	M	HIS	A	A	B	I	2	0
14512	F	HIS	A	I	B	I	1.6	0
14805	M	HIS	AH	AH	A	A	3.2	0
14901	F	Am Ind, HIS	AH	AH	A	A	3.2	1
14902	M	Am Ind, HIS	AH	AH	I	A	2.7	1
14905	F	HIS	A	AH	I	A	2.6	0
15004	F	HIS						0
15010	F	HIS						0
15102	M							0
15801	F	HIS	I	I	A	AH	3.1	0

Note. HIS= Hispanic, Am Ind= American Indian, B = Beginner, I = Intermediate, A = Advanced, AH = Advanced High

Table 2.2 Student Demographics for non-ELLs

Id	Sex	Race
10105	F	HISPANIC
10112	F	HISPANIC
10204	F	AFRICAN AMERICAN
10302	F	AFRICAN AMERICAN
10303	M	AFRICAN AMERICAN
10904	M	AFRICAN AMERICAN & WHITE
10916	F	HISPANIC
11809	M	AFRICAN AMERICAN
12508	M	AFRICAN AMERICAN
12509	F	HISPANIC & WHITE
13404	F	HISPANIC
13812	F	AFRICAN AMERICAN
14114	F	WHITE
14121	F	AFRICAN AMERICAN
14801	M	AFRICAN AMERICAN
14808	M	AMERICAN INDIAN
14818	F	AFRICAN AMERICAN & WHITE
14823	M	WHITE
15216	F	AFRICAN AMERICAN
15903	F	HISPANIC
15906	M	HISPANIC
15907	F	AFRICAN AMERICAN
16005	F	AFRICAN AMERICAN

The first author played the audio files using a media player and transcribed the data using Microsoft Word. The dialogue from each GRA and student were transcribed. All clear dialogue was transcribed verbatim. Inaudible portions of the transcription were marked with an underscore. For instances during which the student spoke in another language (e.g., Spanish), the first author transcribed the audio in the student's native language.

After the audio files were transcribed the author used a coding form (see Appendix A) for each word problem. The first author created the coding form, which was used to identify themes and schemas in the responses of the students for each problem.

CHAPTER THREE: RESULTS

Word-Problem 1 ELLs

For the first word problem, all of the students in the ELL category responded to the questions that the examiner presented to them. Of the 18 students, 39% of students answered the problem correctly. When discussing addition and subtraction, 39% of students discussed addition, and 28% discussed subtraction. When looking at the explanations that the students provided, one student (6%) discussed regrouping. One student (6%) responded with "I don't know," and one student (6%) responded with "I just know." There were two students (11%) who responded with "I counted" or discussed counting. Of the 18 students, 10 used the correct numbers (55%) and 2 counted their numbers out loud (11%). One student (6%) discussed the total schema in the response. For this specific word problem, all students spoke in English. For the first word problem, the average word count for the students was 21.83 words, with a range from 1 to 44 words.

Word-Problem 1 non-ELLs

For the first word problem, 22 students (96%) in the non-ELL category responded to the questions that the examiner presented to them. Of the 23 students, 21% of students (5 students) answered correctly. When discussing addition and subtraction, 34% of students (8 students) discussed addition and 17% of students (4 student) discussed subtraction. When looking at the explanations that the students provided, 1 student (4%) discussed regrouping. Four students (17%) responded with "I counted" or discussed

counting. Of the 23 students, 11 students (48%) used the correct numbers. One student (4%) counted out loud and one student (4%) discussed schemas. Twenty-two students (96%) answered in English. For Word Problem 1, the average word count was 31.77 words with a range of 1 to 141 words.

Table 3.1 Response Percentage Problem 1

Response Percentage Problem 1		
ELL: $n = 18$ Non-ELL: $n = 23$	ELL	Non-ELL
Did the student provide a response?	100%	96%
Did the student respond correctly?	38%	22%
Did the student discuss addition?	38%	35%
Did the student discuss subtraction?	28%	17%
Did the student discuss regrouping?	6%	17%
Did the student respond with "I don't know."	6%	0%
Did the student respond with "I just know."	6%	0%
Did the student respond with "I counted."	11%	17%
Did the student use the correct numbers?	56%	48%
Did the student count out loud?	11%	4%
Did the student discuss schemas (Total, Difference, Change)	6%	4%
Did the student only respond in English?	100%	96%

Word-Problem 2 ELLs

For the second word problem, all of the students in the ELL category responded to the questions the examiner presented to them. Of the 18 students, 44% of students (8 students) answered the problem correctly. When discussing addition and subtraction, 50% of students (9 students) discussed addition and 38% (7 students) of students discussed subtraction. Upon examination of the explanations that the students provided, one student (6%) responded by saying "I don't know." Two students (11%) responded with "I counted" or discussed counting. Of the 18 students, 13 students (72%) used the correct numbers. One student (6%) discussed counting up. Of all the students, 17 (94%) answered in English only. For Word Problem 2, the average word count was 24.55 words with a range from 2 to 69 words.

Word-Problem 2 non-ELLs

For the second word problem, 22 students (96%) in the non-ELL category responded to the questions the examiner presented to them. Of the 23 students, 57% of students (13 students) answered correctly. When discussing addition and subtraction, 39% of students (9 students) discussed addition and 35% of students (8 student) discussed subtraction. When looking at the explanations that the students provided, 2 students (9%) discussed regrouping and 3 students (13%) responded with "I don't know." Six students (26%) responded with "I counted" or discussed counting. Of the 23 students, 11 students (48%) used the correct numbers. Two students (9%) counted out loud and

one student (4%) discussed schemas. All students (23) answered in English. For Word Problem 2, the average word count was 48.35 words with a range of 3 to 301 words.

Table 3.2 Response Percentage Problem 2

Response Percentage Problem 2		
ELL: $n = 18$ Non-ELL: $n = 23$	ELL	Non-ELL
Did the student provide a response?	100%	96%
Did the student respond correctly?	44%	57%
Did the student discuss addition?	50%	39%
Did the student discuss subtraction?	39%	35%
Did the student discuss regrouping?	0%	9%
Did the student respond with “I don’t know.”	6%	13%
Did the student respond with “I just know.”	0%	0%
Did the student respond with “I counted.”	11%	26%
Did the student use the correct numbers?	72%	48%
Did the student count out loud?	0%	9%
Did the student discuss schemas (Total, Difference, Change)	6%	4%
Did the student only respond in English?	94%	100%

Word-Problem 3 ELLs

For the third word problem, all of the students in the ELL category responded to the questions the examiner presented to them. Of the 18 students, 44% of students (8 students) answered correctly. When discussing addition and subtraction, 55% of students (10 students) discussed addition and 6% of students (1 student) discussed subtraction. When looking at the explanations that the students provided, one (6%) student responded with "I don't know," and one student (6%) responded with "I counted" or discussed counting. Of the 18 students, 10 students (55%) used the correct numbers. All students (18) answered in English. For Word Problem 3, the average word count was 23.33 words with a range of 8 to 51 words.

Word-Problem 3 non-ELLs

For the third word problem, 22 students (96%) in the non-ELL category responded to the questions the examiner presented to them. Of the 23 students, 43% of students (10 students) answered correctly. When discussing addition and subtraction, 35% of students (8 students) discussed addition and 17% of students (4 students) discussed subtraction. When looking at the explanations that the students provided, two students (9%) responded with "I don't know," and four students (17%) responded with "I counted" or discussed counting. Of the 23 students, 13 students (57%) used the correct numbers. Four students (17%) counted out loud and one student (4%) discussed schemas. All students (23) answered in English. For Word Problem 2, the average word count was 32.83 words with a range of 7 to 92 words.

Table 3.3 Response Percentage Problem 3

Response Percentage Problem 3		
ELL: $n = 18$ Non-ELL: $n = 23$	ELL	Non-ELL
Did the student provide a response?	100%	96%
Did the student respond correctly?	44%	43%
Did the student discuss addition?	56%	35%
Did the student discuss subtraction?	6%	17%
Did the student discuss regrouping?	0%	0%
Did the student respond with "I don't know."	6%	13%
Did the student respond with "I just know."	0%	0%
Did the student respond with "I counted."	6%	17%
Did the student use the correct numbers?	56%	57%
Did the student count out loud?	0%	17%
Did the student discuss schemas (Total, Difference, Change)	0%	4%
Did the student only respond in English?	100%	100%

Word-Problem 4 ELLs

For the fourth word problem, all of the students in the ELL category responded to the questions the examiner presented to them. Of the 18 students, 22% of students (4 students) answered correctly. When discussing addition and subtraction, 72% of students

(13 students) discussed addition and 6% of students (1 student) discussed subtraction. When looking at the explanations that the students provided, four students (22%) responded with “I counted” or discussed counting. Of the 18 students, 13 students (72%) used the correct numbers. One student (6%) counted out loud and two students (11%) discussed schemas. All students (18) answered in English. For Word Problem 4, the average word count was 22.33 words with a range of 5 to 75 words.

Word-Problem 4 non-ELLs

For the fourth word problem, 22 students (96%) in the non-ELL category responded to the questions the examiner presented to them. Of the 23 students, 39% of students (9 students) answered correctly. When discussing addition and subtraction, 74% of students (17 students) discussed addition and17% of students (4 student) discussed subtraction. When looking at the explanations that the students provided, three students (13%) discussed regrouping and 2 students (9%) responded with “I don’t know.” Six students (26%) responded with “I counted” or discussed counting. Of the 23 students, 15 students (65%) used the correct numbers. Five students (22%) counted out loud and four students (17%) discussed schemas. All students (n = 23) answered in English. For Word Problem 4, the average word count was 34.61 words with a range of 6 to 107 words.

Table 3.4 Response Percentage Problem 4

Response Percentage Problem 4		
ELL: $n = 18$ Non-ELL: $n = 23$	ELL	Non-ELL
Did the student provide a response?	100%	96%
Did the student respond correctly?	22%	39%
Did the student discuss addition?	72%	74%
Did the student discuss subtraction?	6%	17%
Did the student discuss regrouping?	0%	13%
Did the student respond with “I don’t know.”	0%	9%
Did the student respond with “I just know.”	0%	0%
Did the student respond with “I counted.”	22%	26%
Did the student use the correct numbers?	72%	65%
Did the student count out loud?	6%	21%
Did the student discuss schemas (Total, Difference, Change)	22%	17%
Did the student only respond in English?	100%	100%

Word-Problem 5 ELLs

For the fifth word problem, 17 students (94%) in the ELL category responded to the questions the examiner presented to them. Of the 18 students, 16% of students (3 students) answered correctly. When discussing addition and subtraction, 33% of students

(6 students) discussed addition and no students discussed subtraction. When looking at the explanations that the students provided, one student (6%) responded with "I counted" or discussed counting. Of the 18 students, 10 students (55%) used the correct numbers. One student (6%) counted out loud and one student (6%) discussed schemas. Sixteen students (88%) answered in English. For Word Problem 4, the average word count was 28.88 words with a range of 0 to 78 words.

Word-Problem 5 non-ELLs

For the fifth word problem, all students in the non-ELL category responded to the questions the examiner presented to them. Of the 23 students, 35% of students (8 students) answered correctly. When discussing addition and subtraction, 26% of students (6 students) discussed addition and17% of students (4 student) discussed subtraction. When looking at the explanations that the students provided, six students (26%) responded with "I counted" or discussed counting. Of the 23 students, 13 students (57%) used the correct numbers. Four students (17%) counted out loud and two students (17%) discussed schemas. Twenty-three students answered in English. For Word Problem 5, the average word count was 33.91 words with a range of 11 to 122 words.

Table 3.5 Response Percentage Problem 5

Response Percentage Problem 5		
ELL: $n = 18$ Non-ELL: $n = 23$	ELL	Non-ELL
Did the student provide a response?	94%	100%
Did the student respond correctly?	16%	38%
Did the student discuss addition?	33%	26%
Did the student discuss subtraction?	0%	17%
Did the student discuss regrouping?	0%	0%
Did the student respond with “I don’t know.”	0%	0%
Did the student respond with “I just know.”	0%	0%
Did the student respond with “I counted.”	6%	26%
Did the student use the correct numbers?	56%	57%
Did the student count out loud?	6%	17%
Did the student discuss schemas (Total, Difference, Change)	6%	9%
Did the student only respond in English?	89%	100%

Comparison Between Word Count

Of the ELLs who answered the first problem correctly, the minimum word count was 7 and the largest word count was 42. For the same problem, the word count for the non-ELLs who answered correctly ranged from 6 to 141 words. For the second word

problem, the word count for the ELLs who answered correctly ranged from 9 to 42 words. For the same problem, the word count for non-ELLs who answered correctly ranged from 6 to 301 words. For the third problem, the word count for the ELLs who answered correctly was from 8 to 51 words. For non-ELLs who answered the third problem correctly, the word count ranged from 7 to 92 words. For the third word problem, the word count for ELLs who answered correctly ranged from 5 to 32 words. For the same problem, the word count for non-ELLs ranged from 7 to 103. Lastly, on word problem 5, the ELL word count ranged from 27 to 26 and for non-ELLs who answered correctly, the word count ranged from 11 to 110. The trend illustrates that ELLs who answered the problem correctly, on average, used less words than non-ELLs except on word problem 5. In word problem 5, the average word count for ELLs who answered correctly was 32.3 and the average for non-ELLs was 31.75.

An independent-samples *t*-test was conducted to compare word count of students who were ELL and non-ELL. There was a significant difference in the scores for ELL ($M = 24.19$, $SD = 16.84$) and non-ELL ($M = 36.02$, $SD = 38.61$) conditions; $t(203) = 2.710$, $p = .0073$). Specifically, these results suggest that when students are identified as non-ELLs, they use more words when explaining word problems and when students are identified as ELLs, they use less words when explaining word problems.

Table 3.6. *t*-test Results Comparing ELLs and non-ELLs on Word Count

	ELL	Non-ELL
M	24.19	36.02
SD	16.84	38.61
N	90	115
SEM	90	115
p-value	.0073	

Mathematics Vocabulary

Another component of the transcription coding included mathematics vocabulary. The first author compiled all the mathematics vocabulary utilized by the students within each category (ELL or non-ELL) for each problem. For problem 1, ELLs' vocabulary focused on "counting" and "numbers." Non-ELLs vocabulary focused on "adding," "minus," and "equals." For problem 2, ELLs' used "subtract" and non-ELLs used "adding." For problem 3, ELLs' used the words "plus" and "more than." Non-ELLs' on problem 3 focused on "counting up," "add," and "more." For problem 4, both groups used "add," "count," "equals," and "plus." The main difference for problem 4 was that non-ELLs' discussed "subtraction." For the final word problem, ELLs' discussed "adding" while non-ELLs' discussed "counting back," "subtract," and "minus."

For the first word problem, students were expected to subtract; 5 ELLs and 4 non-ELLs spoke the word subtraction within their rationale's. For the second word problem, students were expected to add; 9 ELLs and 9 non-ELLs used the word "addition." For the third word problem, the students were expected to add; 10 ELLs and 8 non-ELLs

discussed addition. For the fourth word problem, students were expected to subtract; 1 ELL and 4 non-ELLs discussed subtraction. For the fifth word problem, the students also were expected to subtract; 0 ELLs and 4 non-ELLs discussed subtraction.

CHAPTER FOUR: DISCUSSION

In this descriptive study, we analyzed transcriptions of third-grade students' responses to word problems, mainly to determine if ELLs approach word-problem solving differently than non-ELLs and to determine any existing differences were a function of language.

When examining the number of students who answered the questions correctly, more non-ELLs answered correctly for every problem presented. Interestingly, for every word problem more than 50% of ELLs used the correct numbers in their calculations. The number of students who used the correct numbers was higher than the numbers of students who answered the problem correctly, for all five word problems. Thus, students were using the correct numbers in their problem solving, but failed to employ the correct operations or performing the calculations correctly.

Word Count

When analyzing average number of words that the students used, non-ELLs spoke more words as compared to ELLs. An unpaired *t*-test was conducted to determine if mean difference existed between the two independent groups (ELLs and non-ELLs). The two-tailed *p*-value was .0073. Therefore, the count of ELLs and non-ELLs had statistically significant differences. The mean word count was 24.19 for ELLs and 36.02 for non-ELLs. The range for the number of words that non-ELLs used was greater than ELLs.

Mathematics Vocabulary

Results indicated that the mathematics vocabulary used by the students differed between groups for every problem. The trends that emerged within the ELLs' vocabulary included a discussion about signs and operations, as compared to non-ELLs who described more about the approach they used to solve the problem (i.e., counted up, more than).

Further Observations

Additional observations emerged for students who presented as dual-language learners and for students who spoke limited English. Notably, only one student spoke in English and Spanish across the word problems. This finding may reflect the testing protocol, in which the examiner was required only to speak in English throughout all three sessions. Even though a majority of students spoke in only English, some students struggled to correctly conjugate words in English due to the language barrier. For problem 1, only one non-ELL discussed using upwards and downwards math or counting up schemas. In the second problem, two ELLs discussed schemas, the first discussed "hitting" the numbers but when elaborating, she used "hit" as the counting up schema. The second ELL discussed using upwards and downwards math or counting up schemas. For word problems 3, 4 and 5, the schemas followed the same pattern of discussing counting up or down from one number to another. The schemas that students used were similar to those present in the UT Word Problem Study but not exactly the same. Within the UT Word Problem Study, the schemas that are taught within the intervention are

Total, Difference and Change, all of which correspond to a type of additive word-problem.

In addition, for word problems 1, 2 and 3, no ELLs counted aloud; seven non-ELLs counted aloud across the three word problems. For problems 4 and 5, one ELL counted aloud for each problem and nine non-ELLs counted aloud. One rationale for why ELLs tend to not count aloud could be because the pretest was being proctored in English. Of the two ELLs who counted aloud, only one answered correctly. If the instruction had been provided in Spanish, ELL students may have been encouraged to count aloud as their Spanish language skills are stronger than their English.

Across the five word problems, both groups discussed addition, even when the problem did not call for it. ELLs were more likely to use terms such as “number,” “more than,” and “difference” whereas non-ELLs were more likely to use words like “counted,” “counted backwards,” “counted up,” and “took away.”

CHAPTER FIVE: LIMITATIONS, IMPLICATIONS, AND CONCLUSION

Limitations

Although the results indicate that the students' word-problem performance and answers were a function of language, limitations emerged during data collection and should be considered when interpreting the results of this study. First, this descriptive study included a small sample size of 18 ELLs and 23 non-ELLs. Thus, the small sample size cannot generalize to larger populations. Replication of this study with a larger sample size should be considered to better understand how ELLs approach word problems in English and Spanish. Furthermore, few studies have been conducted with ELLs and mathematics for comparison of results. The first author was the only researcher to transcribe the audio files within this study and because only transcriptions were used (rather than an analysis of student responses on the paper assessment), a student may have written the correct answer on the assessment, but may have not explained it correctly to the examiner. Future research may use multiple data sources including transcriptions of audio tapes and the copies of student responses on paper assessments to determine if discrepancies exist between what was said aloud and what was written.

Implications for Practice

Implications from this study focus on mathematical instruction within school settings. Implications for practice include administering assessments in the students' native languages and providing greater opportunities for mathematics instruction for ELL students. Educators should consider administering assessments in the native language of

an ELL when possible to support the students' understanding of mathematical concepts. Current mathematics assessments evaluate students' mathematics knowledge, reading comprehension, and language use. Assessments should be provided in students' native language to ensure results accurately reflect students' abilities. Second, educators need to provide greater opportunities to ELLs to speak about mathematics. Many students have few opportunities to talk about mathematics on a regular basis, and more practice using oral language to explain mathematics concepts and procedures may be helpful. Embedding mathematical concepts into language arts lessons could assist with exposure to mathematical concepts and oral practice.

Research Implication

The time frame for this study was limited to four months because of thesis guideline dates. Future research should compare how ELLs performed on the Texas Word Problem section from pretest to posttest. By comparing students' pretest and posttest responses, one could determine the extent to which each group performed differently before and after the word-problem intervention. Future research also should consider comparing students' performances within the ELL group, specifically for students who spoke a language other than Spanish (i.e., Spanish speakers compared to Hmong speakers).

Conclusion

This study extends previous research (Ríordáin, 2008; Neville-Barton and Barton, 2005) that indicates that ELLs and non-ELLs approach and solve word problems

differently. Specific components that differed between the groups were word count and vocabulary. These results may reflect the assessment protocol, which was administered in English and the limited opportunities presented to ELLs to discuss mathematics within their classroom contexts. ELLs are a student population that is largely overlooked and a significant need exists to provide ELLs with the appropriate supports to ensure their success in mathematics and to equip them with the skills necessary to succeed beyond high school.

APPENDIX A: CODING FORM

Participant: _____

Problem Number: _____

(S-1 , T-2, U-3, V-4, W-5)

Did the student give a response? Y N

Did the student get the problem correct? Y N

Did the student use operations?

Addition Y N

What was added? _____

Subtraction Y N

What was subtracted? _____

Did the student discuss regrouping (regroup, carry, move from ones to tens etc..)? Y N

Was the student's response "I don't Know"? Y N

Was the student's response "I just know"? Y N

Was the student's response "I just counted?" Y N

Did the student use the correct numbers? Y N

Did the student count out loud? Y N

Did the student use schemas (Total, Difference, Change)? Y N

Did the student speak ONLY in English? Y N (What language was spoken: _____)

Did the student use Math Vocabulary? Y N

Procedural vocabulary: _____

Conceptual vocabulary: _____

Was the problem reread? Y N

Rating: 1 2 3 4 5

Word Count (including Numbers): 

Length of Session: 

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